

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

Claim 1 (previously presented): A method of forming a metal container of defined shape and lateral dimensions, comprising

(a) disposing a hollow metal preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, with only a single, movable punch, said punch being located at one end of the cavity and translatable into the cavity, the preform closed end being positioned in proximate facing relation to the punch and at least a portion of the preform being initially spaced inwardly from the die wall;

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity; and

(c) translating the punch into the cavity to engage and displace the closed end of the preform in a direction opposite to the direction of force exerted by fluid pressure thereon, deforming the closed end of the preform.

Claim 2 (canceled)

Claim 3 (original): A method according to claim 1, wherein the punch is moved into contact with the closed end of the preform before commencing expansion of the preform and the contact is maintained throughout the expansion of the preform.

Claim 4 (original): A method according to claim 1, wherein said punch has a contoured surface, the closed end of the preform being deformed so as to conform to said contoured surface.

Claim 5 (original): A method according to claim 1, wherein said defined shape is a bottle shape including a neck portion and a body portion larger in lateral dimensions than the neck portion, said die cavity having a long axis, said preform having a long axis and being disposed substantially coaxially with said cavity in step (a), and said punch being translatable along the long axis of the cavity.

Claim 6 (original): A method according to claim 5, wherein said punch has a domed contour, and wherein step (c) deforms said closed end of said preform into said domed contour.

Claim 7 (original): A method according to claim 5, wherein said die wall comprises a split die separable for removal of the formed container following step (c).

Claim 8 (original): A method according to claim 7, wherein said defined shape is asymmetric about said long axis of said cavity.

Claim 9 (original): A method according to claim 5, wherein said punch is initially positioned, at the start of step (b), to limit axial lengthening of the preform by said fluid pressure.

Claim 10 (canceled)

Claim 11 (original): A method according to claim 5, wherein said preform is an elongated and initially generally cylindrical

workpiece having an open end opposite said closed end and is substantially equal in diameter to said neck portion of said bottle shape.

Claim 12 (original): A method according to claim 11, wherein said workpiece has sufficient formability to be expandable to said defined shape in a single pressure forming operation.

Claim 13 (original): A method according to claim 11, including a preliminary steps of placing the workpiece in a die cavity smaller than the first-mentioned die cavity and subjecting the workpiece therein to internal fluid pressure to expand the workpiece to an intermediate size and shape smaller than said defined shape and lateral dimensions, before performing steps (a), (b) and (c).

Claim 14 (canceled)

Claim 15 (original): A method according to claim 1, wherein said preform is an aluminum preform.

Claims 16 - 19 (canceled)

Claim 20 (original): A method according to claim 1, wherein step (b) comprises simultaneously applying internal positive fluid pressure and external positive fluid pressure to the preform in the cavity, said internal positive fluid pressure being higher than said external positive fluid pressure.

Claim 21 (canceled)

Claim 22 (original): A method according to claim 3, wherein heat is applied to the preform by way of heating means in the punch to thereby induce a temperature gradient to the preform commencing at the closed bottom and extending upwardly.

Claim 23 (canceled)

Claim 24 (original): A method according to claim 22, wherein heat is applied to the preform by way of heating means in the side walls of the die.

Claims 25 - 31 (canceled)

Claim 32 (original): A method according to claim 1, wherein the die wall comprises die structure having upper and lower portions and wherein heat is applied to the preform by two groups of heating elements respectively incorporated in the upper and lower portions of the die structure and under independent temperature control for controlling temperature gradient in the preform.

Claim 33 (original): A method according to claim 1, wherein heat is applied to the preform by a heating element disposed within the preform substantially coaxially therewith.

Claim 34 (original): A method according to claim 33 wherein heat is further supplied to the preform by heating the punch.

Claims 35 - 45 (canceled)

Claim 46 (previously presented): A method according to claim 1, wherein said fluid pressure is provided by gas.

Claim 47 (previously presented): A method of forming a metal container of defined shape and lateral dimensions, comprising

(a) disposing a hollow metal preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, with a punch located at one end of the cavity and translatable into the cavity, the preform closed end being positioned in proximate facing relation to the punch and at least a portion of the preform being initially spaced inwardly from the die wall;

(b) subjecting the preform to internal gas pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said gas pressure exerting force, on said closed end, directed toward said one end of the cavity; and

(c) translating the punch into the cavity to engage and displace the closed end of the preform in a direction opposite to the direction of force exerted by gas pressure thereon, deforming the closed end of the preform.

Claim 48 (new): A method of forming a metal container of defined shape and lateral dimensions, comprising the steps of

(a) disposing a hollow metal preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, the preform closed end being positioned in facing relation to one end of the cavity and at least a portion of the preform being initially spaced inwardly from the die wall, and

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity,

wherein step (b) comprises simultaneously applying internal positive fluid pressure and external positive fluid pressure to the preform in the cavity, said internal positive fluid pressure being higher than said external positive fluid pressure,

and including controlling strain rate in the preform by independently controlling the internal and external positive fluid pressures to which the preform is simultaneously subjected for varying the differential between said internal positive fluid pressure and said external positive fluid pressure.

Claim 49 (new): A method of forming a metal container of defined shape and lateral dimensions, comprising

(a) disposing a hollow metal preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, with a punch located at one end of the cavity and translatable into the cavity, the preform closed end being positioned in proximate facing relation to the punch and at least a portion of the preform being initially spaced inwardly from the die wall;

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity; and

(c) translating the punch into the cavity to engage and displace the closed end of the preform in a direction opposite to the direction of force exerted by fluid pressure thereon, deforming the closed end of the preform,

wherein step (b) comprises simultaneously applying internal positive fluid pressure and external positive fluid pressure to the preform in the cavity, said internal positive fluid pressure

being higher than said external positive fluid pressure, and wherein said metal is aluminum.

Claim 50 (new): A method according to claim 49, wherein said fluid pressure is provided by gas.

Claim 51 (new): A method according to claim 50, wherein steps (b) and (c) are performed at a temperature higher than 100°C.

Claim 52 (new): A method according to claim 47, wherein steps (b) and (c) are performed at a temperature higher than 100°C.

Claim 53 (new): A method according to claim 47, wherein steps (b) and (c) are performed at a temperature of about 300°C.

Claim 54 (new): A method according to claim 49, including controlling strain rate in the preform by independently controlling the internal and external positive fluid pressures to which the preform is simultaneously subjected for varying the differential between said internal positive fluid pressure and said external positive fluid pressure.

Claim 55 (new): A method according to claim 54, wherein said internal positive fluid pressure is provided by gas.

Claim 56 (new): A method according to claim 55, wherein both said internal and external positive fluid pressures are provided by gas.

Claim 57 (new): A method according to claim 55, wherein steps (b) and (c) are performed at a temperature higher than 100°C.

Claim 58 (new): A method of forming an aluminum container of defined shape and lateral dimensions, comprising

(a) disposing a hollow aluminum preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, with a punch located at one end of the cavity and translatable into the cavity, the preform closed end being positioned in proximate facing relation to the punch and at least a portion of the preform being initially spaced inwardly from the die wall;

(b) subjecting the preform to internal gas pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said gas pressure exerting force, on said closed end, directed toward said one end of the cavity; and

(c) translating the punch into the cavity to engage and displace the closed end of the preform in a direction opposite to the direction of force exerted by gas pressure thereon, deforming the closed end of the preform,

further including the step of making the preform from aluminum sheet having a recrystallized or recovered microstructure with a gauge in a range of about 0.25 to about 1.5 mm, prior to performance of step (a).

Claim 59 (new): A method according to claim 58, wherein steps (b) and (c) are performed at a temperature higher than 100°C.

Claim 60 (new): A method according to claim 58, wherein step (b) comprises simultaneously applying internal positive fluid pressure and external positive fluid pressure to the preform in the cavity, said internal positive fluid pressure being higher than said external positive fluid pressure,

and including controlling strain rate in the preform by independently controlling the internal and external positive fluid pressures to which the preform is simultaneously subjected for varying the differential between said internal positive fluid pressure and said external positive fluid pressure.

Claim 61 (new): A method according to claim 47, wherein said gas is selected from the group consisting of nitrogen, air and argon.

Claim 62 (new): A method according to claim 51, wherein said gas is selected from the group consisting of nitrogen, air and argon.

Claim 63 (new): A method according to claim 55, wherein said gas is selected from the group consisting of nitrogen, air and argon.

Claim 64 (new): A method according to claim 59, wherein said gas is selected from the group consisting of nitrogen, air and argon.

Claim 65 (new): A method of forming an aluminum container of defined shape and lateral dimensions, comprising

(a) disposing a hollow aluminum preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, the preform closed end being positioned in facing relation to one end of the cavity and at least a portion of the preform being initially spaced inwardly from the die wall; and

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with

the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity;

further including the step of making the preform from aluminum sheet having a recrystallized or recovered microstructure with a gauge in a range of about 0.25 to about 1.5 mm, prior to performance of step (a).

Claim 66 (new): A method of forming an aluminum container of defined shape and lateral dimensions, comprising

(a) disposing a hollow aluminum preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, the preform closed end being positioned in facing relation to one end of the cavity and at least a portion of the preform being initially spaced inwardly from the die wall; and

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity;

wherein said defined shape is a bottle shape including a neck portion and a body portion larger in lateral dimensions than the neck portion, said die cavity having a long axis, said preform having a long axis and being disposed substantially coaxially with said cavity in step (a);

wherein said preform is an elongated and initially generally cylindrical workpiece having an open end opposite said closed end and is substantially equal in diameter to said neck portion of said bottle shape; and

including preliminary steps of placing the workpiece in a die cavity smaller than the first-mentioned die cavity and subjecting

the workpiece therein to internal fluid pressure to expand the workpiece to an intermediate size and shape smaller than said defined shape and lateral dimensions, before performing steps (a) and (b).

Claim 67 (new): A method according to claim 66, further including the step of making the preform from aluminum sheet having a recrystallized or recovered microstructure with a gauge in a range of about 0.25 to about 1.5 mm, prior to performance of step (a).

Claim 68 (new): Apparatus for forming a metal container of defined shape and lateral dimensions from a hollow metal preform having a closed end, comprising

(a) die structure providing a die cavity for receiving the preform therein with at least a portion of the preform being initially spaced inwardly from the die wall and the preform closed end facing one end of the cavity, said cavity having a die wall defining said shape and lateral dimensions;

(b) a fluid pressure supply for subjecting a preform within the cavity to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity;

(c) the die cavity having a second end opposed to said one end and an axis extending therebetween;

(d) the die wall comprising a split die including a plurality of split inserts disposed in tandem along said axis for defining successive portions of said shape and separable for removal of the formed container from the cavity.

Claim 69 (new): Apparatus as defined in claim 68, wherein the die structure comprises a split holder within which the split inserts are removably and replaceably received, for maintaining the inserts in fixed die-cavity-defining position during expansion of a preform within the cavity.

Claim 70 (new): Apparatus as defined in claim 69, wherein at least one of said inserts has an inner surface bearing a relief feature for imparting a corresponding relief feature to the container.

Claim 71 (new): Apparatus as defined in claim 70, further comprising a group of interchangeable inserts having inner surfaces respectively bearing different relief features, from which one or more split inserts are selected for insertion in said holder.

Claim 72 (new): Apparatus as defined in claim 68, further including separate gas-feeding channels for respectively feeding gas to the interior of the preform and to the die cavity externally of the preform, to apply internal and external positive fluid pressures to a preform within the die cavity.

Claim 73 (new): Apparatus as defined in claim 68, wherein the die structure has upper and lower portions and two groups of heating elements respectively incorporated in the upper and lower portions of the die structure and under independent temperature control for controlling temperature gradient in the preform.

Claim 74 (new): Apparatus as defined in claim 68, further including a heating element insertable within a preform in the die cavity substantially coaxially therewith.

Claim 75 (new): Apparatus as defined in claim 68, wherein the neck portion of the defined shape includes a screw thread or lug for securing a screw closure to the formed container and wherein the die wall has a neck portion with a thread or lug formed therein for imparting a thread or lug to a preform disposed in the die cavity.

Claim 76 (new): A method of forming a hollow metal article of defined shape and lateral dimensions, comprising

(a) disposing a hollow metal preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, with only a single, movable punch, said punch being located at one end of the cavity and translatable into the cavity, the preform closed end being positioned in proximate facing relation to the punch and at least a portion of the preform being initially spaced inwardly from the die wall;

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity; and

(c) translating the punch into the cavity to engage and displace the closed end of the preform in a direction opposite to the direction of force exerted by fluid pressure thereon, deforming the closed end of the preform.

Claim 77 (new): A method of forming a hollow metal article of defined shape and lateral dimensions, comprising

(a) disposing a hollow metal preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, with a punch located at one end of the cavity and translatable into the cavity, the preform closed end

being positioned in proximate facing relation to the punch and at least a portion of the preform being initially spaced inwardly from the die wall;

(b) subjecting the preform to internal gas pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said gas pressure exerting force, on said closed end, directed toward said one end of the cavity; and

(c) translating the punch into the cavity to engage and displace the closed end of the preform in a direction opposite to the direction of force exerted by gas pressure thereon, deforming the closed end of the preform.

Claim 78 (new): A method of forming a hollow metal article of defined shape and lateral dimensions, comprising the steps of

(a) disposing a hollow metal preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, the preform closed end being positioned in facing relation to one end of the cavity and at least a portion of the preform being initially spaced inwardly from the die wall, and

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity,

wherein step (b) comprises simultaneously applying internal positive fluid pressure and external positive fluid pressure to the preform in the cavity, said internal positive fluid pressure being higher than said external positive fluid pressure,

and including controlling strain rate in the preform by independently controlling the internal and external positive fluid pressures to which the preform is simultaneously subjected for

varying the differential between said internal positive fluid pressure and said external positive fluid pressure.

Claim 79 (new): A method of forming a hollow metal article of defined shape and lateral dimensions, comprising

(a) disposing a hollow metal preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, with a punch located at one end of the cavity and translatable into the cavity, the preform closed end being positioned in proximate facing relation to the punch and at least a portion of the preform being initially spaced inwardly from the die wall;

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity; and

(c) translating the punch into the cavity to engage and displace the closed end of the preform in a direction opposite to the direction of force exerted by fluid pressure thereon, deforming the closed end of the preform,

wherein step (b) comprises simultaneously applying internal positive fluid pressure and external positive fluid pressure to the preform in the cavity, said internal positive fluid pressure being higher than said external positive fluid pressure, and wherein said metal is aluminum.

Claim 80 (new): A method of forming a hollow aluminum article of defined shape and lateral dimensions, comprising

(a) disposing a hollow aluminum preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, with a punch located at one end of

the cavity and translatable into the cavity, the preform closed end being positioned in proximate facing relation to the punch and at least a portion of the preform being initially spaced inwardly from the die wall;

(b) subjecting the preform to internal gas pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said gas pressure exerting force, on said closed end, directed toward said one end of the cavity; and

(c) translating the punch into the cavity to engage and displace the closed end of the preform in a direction opposite to the direction of force exerted by gas pressure thereon, deforming the closed end of the preform,

further including the step of making the preform from aluminum sheet having a recrystallized or recovered microstructure with a gauge in a range of about 0.25 to about 1.5 mm, prior to performance of step (a).

Claim 81 (new): A method of forming a hollow aluminum article of defined shape and lateral dimensions, comprising

(a) disposing a hollow aluminum preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, the preform closed end being positioned in facing relation to one end of the cavity and at least a portion of the preform being initially spaced inwardly from the die wall; and

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity;

further including the step of making the preform from aluminum sheet having a recrystallized or recovered microstructure with a gauge in a range of about 0.25 to about 1.5 mm, prior to performance of step (a).

Claim 82 (new): A method of forming a hollow aluminum article of defined shape and lateral dimensions, comprising

(a) disposing a hollow aluminum preform having a closed end in a die cavity laterally enclosed by a die wall defining said shape and lateral dimensions, the preform closed end being positioned in facing relation to one end of the cavity and at least a portion of the preform being initially spaced inwardly from the die wall; and

(b) subjecting the preform to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity;

wherein said defined shape is a bottle shape including a neck portion and a body portion larger in lateral dimensions than the neck portion, said die cavity having a long axis, said preform having a long axis and being disposed substantially coaxially with said cavity in step (a);

wherein said preform is an elongated and initially generally cylindrical workpiece having an open end opposite said closed end and is substantially equal in diameter to said neck portion of said bottle shape; and

including preliminary steps of placing the workpiece in a die cavity smaller than the first-mentioned die cavity and subjecting the workpiece therein to internal fluid pressure to expand the workpiece to an intermediate size and shape smaller than said

defined shape and lateral dimensions, before performing steps (a) and (b).

Claim 83 (new): Apparatus for forming a hollow metal article of defined shape and lateral dimensions from a hollow metal preform having a closed end, comprising

(a) die structure providing a die cavity for receiving the preform therein with at least a portion of the preform being initially spaced inwardly from the die wall and the preform closed end facing one end of the cavity, said cavity having a die wall defining said shape and lateral dimensions;

(b) a fluid pressure supply for subjecting a preform within the cavity to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity;

(c) the die cavity having a second end opposed to said one end and an axis extending therebetween;

(d) the die wall comprising a split die including a plurality of split inserts disposed in tandem along said axis for defining successive portions of said shape and separable for removal of the formed container from the cavity.

84. Apparatus for forming a hollow metal article of defined shape and lateral dimensions from a hollow metal preform having a closed end, comprising

(a) die structure providing a die cavity for receiving the preform therein with at least a portion of the preform being initially spaced inwardly from the die wall and the preform closed end facing one end of the cavity, said cavity having a die wall defining said shape and lateral dimensions;

(b) a punch located at one end of the cavity and translatable into the cavity such that the closed end of a preform received within the cavity is positioned in proximate facing relation to the punch;

(c) a fluid pressure supply for subjecting a preform within the cavity to internal fluid pressure to expand the preform outwardly into substantially full contact with the die wall, thereby to impart said defined shape and lateral dimensions to the preform, said fluid pressure exerting force, on said closed end, directed toward said one end of the cavity;

(d) the die cavity having a second end opposed to said one end and an axis extending therebetween;

(e) the die wall comprising a split die including a plurality of split inserts disposed in tandem along said axis for defining successive portions of said shape and separable for removal of the formed container from the cavity.